INNOVATIVE TECHNOLOGY
Summary Report

Mobile Characterization System for Large Crates

Deactivation and Decommissioning Focus Area

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INNOVATIVE TECHNOLOGY
Summary Report

Mobile Characterization System for Large Crates

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Deactivation and Decommissioning Focus Area

Demonstrated at
Los Alamos National Laboratory
Los Alamos, New Mexico

INNOVATIVE TECHNOLOGY

Summary Report

Purpose of this document

Innovative Technology Summary Reports are designed to provide potential users with the information they need to quickly determine whether a technology would apply to a particular environmental management problem. They are also designed for readers who may recommend that a technology be considered by prospective users.

Each report describes a technology, system, or process that has been developed and tested with funding from DOE's Office of Science and Technology (OST). A report presents the full range of problems that a technology, system, or process will address and its advantages to the DOE cleanup in terms of system performance, cost, and cleanup effectiveness. Most reports include comparisons to baseline technologies as well as other competing technologies. Information about commercial availability and technology readiness for implementation is also included. Innovative Technology Summary Reports are intended to provide summary information. References for more detailed information are provided in an appendix.

Efforts have been made to provide key data describing the performance, cost, and regulatory acceptance of the technology. If this information was not available at the time of publication, the omission is noted.

All published Innovative Technology Summary Reports are available on the OST Web site at http://www.em.doe.gov/ost under "Reports."

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SECTION 1
SUMMARY

Technology Summary

Problem

The United States Department of Energy (DOE) continually seeks safer and more cost-effective remediation technologies for use in the decontamination and decommissioning (D&D) of nuclear facilities. To this end, the Deactivation and Decommissioning Focus Area (DDFA) of the DOE's Office of Science and Technology sponsors Large-Scale Demonstration and Deployment Projects (LSDDPs) in which developers and vendors of improved or innovative technologies showcase products that are potentially beneficial to the DOE's projects and to others in the D&D community. Benefits sought include decreased health and safety risks to personnel and the environment, increased productivity, and decreased cost of operation.

The LANL inventory of low-level transuranic (TRU) waste includes over 600 large fiberglass reinforced plywood (FRP) crates containing waste such as gloveboxes, tanks, lab equipment, ductwork, filter media, and contaminated soil. Approximately 2400 cubic meters of this waste is currently in storage at the Los Alamos solid waste disposal area, TA-54, and another 3000 cubic meters will be generated as LANL facilities are decommissioned. All of these wastes will be processed in the Los Alamos Decontamination and Volume Reduction System (DVRS). The DVRS, funded through a DDFA Accelerated Site Technology Deployment project will characterize the boxes, decontaminate or segregate to meet low level waste limits, volume reduce the metal in a baler and then dispose on site in TA-54. The TRU fractions will be processed to meet the Waste Acceptance Criteria of the Waste Isolation Pilot Plant (WIPP) by removal of prohibited items, repackaging into appropriate sized drums or boxes, and other applicable WIPP requirements. The constituents of each crate were partially documented during crate loading; however, a detailed picture of the crate contents would greatly facilitate crate dismantlement and contents handling.

The overall objective of this demonstration was to determine whether the large box Real Time Radiography (RTR) system developed by VJ Technologies and operated by Mobile Characterization Services (MCS), is an effective enabling technology for the non-invasive inspection of the waste crates and other containers. The image of container contents provided by the large box RTR system, along with a radiation survey of each container, will allow workers to plan the safest and most efficient approach to open each container and process its contents through DVRS. The DVRS baseline process did not include radiography of the crates because it was not known to be possible.

How It Works

The MCS operated large box RTR system is a VJ Technologies x-ray imaging system to non-intrusively image the contents of waste storage crates and containers. The unit is similar to drum RTR systems for certification of waste packages for WIPP. The large box RTR system is housed in a semi-trailer that weighs approximately 100,000 lbs. To image a waste container, it is loaded onto a turntable trolley conveyor system attached to the trailer and moved into the lead shielded x-ray vault inside the trailer. The maximum container size accepted is 113-inches long by 77-inches wide and 77-inches tall.

Once a container is moved into the vault, the doors are closed and x-ray generation is initiated. X-rays are directed through the container to an image intensifier. Up to 450 Kv can be supplied to the x-ray tube, with the exact power requirements determined by the penetrating power required to image the contents. The image intensifier converts the x-rays into a visible light image which is displayed on a video monitor. The video system includes a videotape cassette recorder (S-VHS) with a microphone and an alpha-numeric character generating drive for either verbal or text narrative.

The system images or radiographs approximately a 6 inch by 6 inch segment at any instant. The combination of the moving trolley conveyor and the elevation control on the x-ray system facilitates imaging of the entire waste container from top to bottom and end to end. The system output is a video recording and associated descriptive narrative of the image as the x-ray head proceeds across and down the container. Large containers are radiographed from both sides. Small containers or containers with simple contents, such as filters, are radiographed from only one side. Image resolution can be enhanced by adjusting the x-ray power or by adjustment of a shutter on the x-ray tube.

The system is designed to meet Washington Bureau of Radiological Health safety standards. The enclosure includes access doors with radiation safety interlocks to prevent x-ray operation with the doors open. Safeguards are also provided inside the x-ray vault, enabling personnel to deactivate the x-ray unit in the unlikely event that the doors were closed while a person was inside the vault.

Figure 1 MCS Large Box RTR Unit

Figure 2 Crate staged on trolley for movement into the RTR trailer

Demonstration Summary

In January 2000 the Integrating Contractor Team (ICT) of the Los Alamos Large Scale Demonstration and Deployment Project demonstrated the Mobile Characterization Services large box RTR system as a part of the Large Scale Demonstration and Deployment Project, funded by the U.S. Department of Energy's Deactivation and Decontamination Focus Area at the National Energy Technology Laboratory. LANL radiation control technicians surveyed the system for potential radiation leakage prior to introduction of any waste crates or containers. Twenty pre-selected containers and items were radiographed during the demonstration. The containers included fiberglass reinforced plywood (FRP) crates, metal Standard Waste Boxes (SWB) and one unknown metal cylinder provided by the LANL waste management operations. The containers were transported to the RTR trailer using a truck or forklift. The forklift placed the containers on the RTR system trolley, and the MCS technicians then initiated imaging. LANL radiation control technicians surveyed the forklift and trolley after each container was radiographed and found no contamination. Integrating Contractor Team test engineers acted as data compilers and reviewers for the demonstration. The demonstration was supervised by LANL Solid Waste Operations staff.

The MCS RTR unit provided detailed radiographic images of the contents of all containers and packages. Items such as plastic bagging, nails in crate construction, electrical connectors, wiring, piping, and fittings were clearly visible. Large metal items were easily located and their position and general shape was understood. Once the container was positioned on the RTR trolley, it took from 15 to 60 minutes to obtain the complete image and associated audio description. The time required for imaging is dependent on both the size of the container and its contents. Containers of filter media required much less detail to review than containers of complex items and miscellaneous trash.

A particularly significant result of the demonstration was the identification of a vessel that contained several gallons of liquid. The liquid was identified by the wave action that was created as the trolley moved through the field of the x-ray head. Wave motion in the vessel was distinct and unmistakable. This result showed a clear benefit of this type of characterization of the waste crates. An aerosol can was also located in a container of mixed trash. The unknown cylinder was found to contain an apparent radiation source. These results have already enhanced the management of these items in the LANL system.

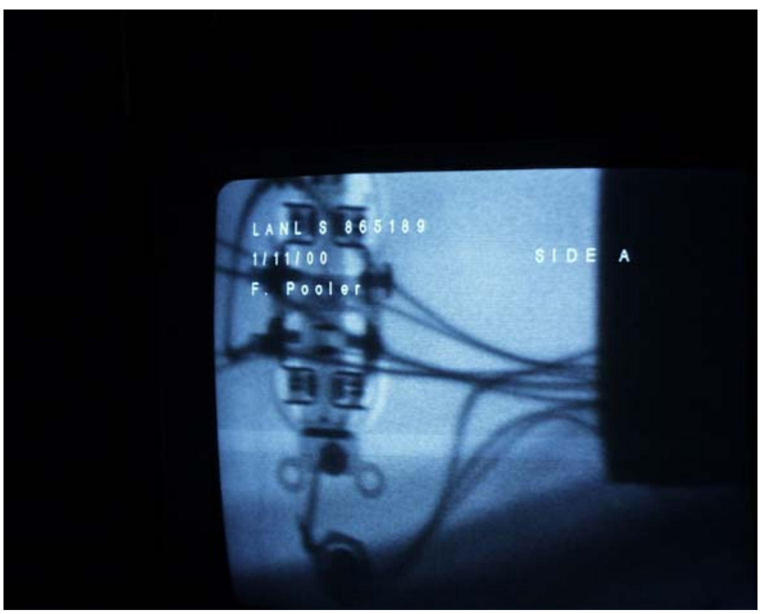

Figure 3 Large Box RTR Image of common electrical outlet

As shown in Figure 3 above, the image clearly reveals the detail of small crated items. The general shape of large items was also discernable, but a single image of the complete crate and contents was not possible with the system, as configured.

The demonstration met or exceeded expectations for enhanced understanding of the waste container contents in support of opening and classification of contents. Radiographic images produced by the large box RTR system will enhance both the container processing planning and worker safety during the container opening process. A cost savings is expected from improved planning that ensures the appropriate materials and equipment will be in-place as the container opening begins. Schedule impact from unknowns encountered during processing will also be minimized. Worker safety will be enhanced by the improved knowledge of the items in the crates and knowledge of the best place to cut into the crates.

A cost estimate for using Large Box RTR system was conducted using a basis of 120 containers. With this basis, the unit cost for Large Box RTR deployment was $1,100 per container. The unit cost drops to $750 if large numbers of containers are radiographed.

Benefits:

- Provides non-invasive radiographs of many large crates and waste containers
- Capable of scanning 12 crates and containers per hour
- Provides input on best location for opening containers
- Provides inventory reconciliation/confirmation
- Facilitates crate selection and scheduling for the DVRS process
- Improves worker safety during opening of waste packages

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Other

All published Innovative Technology Summary Reports are available on the OST Web site at http://ost.em.doe.gov under “Publications.” The Technology Management System (TMS), also available through the OST Web site, provides information about OST programs, technologies, and problems. The OST reference number for the MCS large Box RTR demonstration is #2959.

The Los Alamos LSDDP website address is: http://www-emtd.lanl.gov/LSDDP/DDtech.html.

SECTION 2
TECHNOLOGY DESCRIPTION

Overall Process Definition

The overall objective of the demonstration was evaluation of the MCS large box RTR system for its ability to characterize the contents of the FRP crates and other waste container types at LANL. If successful, the cost and risk of the subsequent waste container processing would be greatly enhanced. Specifically, the safety of crate opening would be enhanced by knowledge of the spatial orientation of the metallic objects and identification of items requiring special handling. In addition, identification of glove boxes with lead shielding will avoid opening a crate of mixed waste without requisite preparations.

The large box RTR unit demonstrated at Los Alamos National Laboratory's TA-54 consisted of a 100,000 lb. lead lined truck trailer containing both the x-ray chamber and operating office. The system was parked near one of the waste storage domes and powered from a LANL service box. Prior to the demonstration a list of pre-approved containers was developed that met the safety requirement of the laboratory for integrity and radionuclide content as well as the size restriction of the RTR system. LANL technicians delivered these containers to the RTR unit and positioned them on the trolley that carried the container into the x-ray chamber. Once on the trolley, MCS technicians operated the system according to established procedures. The maximum container size accepted is 113-inches long by 77-inches wide and 77-inches tall.

Once the container was trolleyed into the x-ray chamber and all safety interlocks were satisfied, imaging began. The image intensifier "sees" about a six inch portion of the container. To image an entire container the horizontal control of the trolley and the vertical control of the x-ray unit are used to traverse each container across and down until the entire package is imaged. The radiographic images and associated observations by the MCS technicians are recorded on video tape. Some containers were radiographed from both sides, while small crates or those with simple contents were radiographed from one side.

System Operation

The large box RTR system used for this demonstration was a new system developed specifically to radiograph large containers of DOE waste using procedures and requirements for certification of waste for emplacement at WIPP. Therefore, there is particular attention paid to containerized liquids and aerosol cans, as well as other items prohibited at WIPP. This unit was constructed by VJ Technologies and operated by Mobile Characterization Services of Albuquerque, New Mexico.

Once a container is in the vault, the shield doors are closed. Interlocks on all doors must be satisfied to initiate x-ray generation. X-rays are produced in the x-ray tube head and are directed through the container to an image intensifier. The image intensifier converts the x-rays into a visible light image, which is displayed on a video monitor. The video system includes a videotape cassette recorder (S-VHS) with a microphone and an alpha-numeric character generating drive for either verbal or text narrative. Crates with complex contents are imaged on both sides. To image the opposite side, the crate is moved from the x-ray chamber using the trolley and once outside it is rotated using a turntable on the trolley.

The penetrating power of the x-rays is routinely, almost continuously, adjusted by the technician as the unit scans the various items in the waste package. The adjustment is mad by a simple dial. Up to 450 Kv can be supplied to the x-ray tube, with the exact power requirements determined by the penetrating power required to image the contents. Dense metal objects, such as vessels, can be penetrated at the high power settings, but those settings "flare" the image for less dense materials and power must be reduced. Figure 4 shows the operator at the console.

Figure 4; MCS Technician at the Large Box RTR System Console.

Operational safety concerns with the large box RTR system included potential radiation hazards associated with the x-ray imaging. To address these concerns, LANL radiation control technicians surveyed the trailer with the x-ray unit energized prior to allowing introduction of any waste crates. No “leakage” was detected. In addition, all interlocks were tested prior to daily operation.

Table 1 Summarizes the system operational parameters.

Table 1. Operational parameters and conditions of the Large Box RTR demonstration

Operational Parameter	Los Alamos Application
Work Area Location	Los Alamos National Laboratory, TA 54
Work Area Description	Asphalt pad adjacent to dome 230
Work Area Hazards	• Movement of vehicles • Potential radiation hazard from x-ray leakage through lead shielding • Potential x-ray initiation with someone in the x-ray chamber • Loading and unloading of large crates
Waste Container Size	• Smallest was approximately 2 ft x 2 ft x 8 ft • Largest was approximately 4 ft x 4 ft x 8 ft
Work Crew	• Two technicians inside the RTR unit, • One fork truck operator • One flatbed truck driver/forklift spotter • One radiation control technician
Additional Support Personnel	Full-time demonstration data taker Demonstration supervisor
Training	• Rad Worker training required for RTR operators • Site specific training on evacuation procedures
Equipment Design Purpose	Non-invasive imaging of waste containers
Dimension	Truck trailer, approximately 12 feet wide by 50 feet long
Personal Protective Equipment	• Safety glasses • Steel toed boots • Hardhats near forklift operations • TLD, ALOKA and alarming dosimeters based on LANL requirements
Utilities	460 volt, 100 amp service

SECTION 3
PERFORMANCE

Demonstration Plan

MCS large box RTR system was delivered and positioned in Los Alamos TA-54 by a commercial driver and it was not moved until demobilization. LANL and MCS technicians removed the trolley system and trolley frame from the trailer and assembled it at the rear door of the trailer. A single electrical cable powered the unit from a site 460-volt supply.

Prior to the demonstration, a list of candidate FRP crates and standard waste boxes (SWBs) was developed for the imaging. The list purposely included FRP crates and other waste containers of varying size and different content descriptions. The candidate FRP crates and containers were also evaluated for integrity to ensure that they would withstand loading and unloading. Their radionuclide content was also a screening criteria that ensured compliance with the site safety requirements. The RTR system opening limits container sizes to 113-inches long by 77-inches wide and 77-inches tall. The size restriction eliminated approximately 75% of the candidate crated gloveboxes. It is noted that the unit specifically addresses radiography according to the requirements of the WIPP, and it readily demonstrated radiography of SWBs, a typical WIPP waste package.

Waste containers were stored in one of two fabric domes less than one-quarter mile from the RTR trailer. Some containers were transported using a forklift directly from the storage dome to the RTR system, while others were transported using a flatbed truck. Radiation control technicians (RCTs) were present to scan the containers during loading and offloading.

Prior to any container radiography, LANL radiation control technicians collected radiation data around all x-ray chamber doors and outside the trailer with the x-ray head energized. No “leakage” was detected at any location.

The demonstration execution was conducted according to an approved test plan (IT Corporation, 1999). As part of the demonstration, the time for radiography of each waste container was recorded. Other time data recorded included mobilization, daily preparation time, plans and permits meetings, and demobilization. Labor requirements were also recorded for these tasks. Labor costs included demonstration personnel, support personnel, and labor costs for plans and permits. The video images and associated narrative of observations was saved for future use when these packages are opened.

The overall test objective of the demonstration was to assess the feasibility and utility of radiography of LANL FRP crates and waste containers. Specific demonstration objectives were:

- Image the contents of oversize waste containers such as large boxes and crates to identify the content of the crates, specifically whether the crates include lead shielding
- Identification of lead shielding in the objects to identify crates that are mixed waste
- Through content resolution, enhance the health and safety as well as the efficiency of crate opening and subsequent contents handling
- Through content resolution, enable an assessment of the site-specific programmatic resources required for TRU oversize waste handling, i.e., manpower forecasting
- Confirm container contents inventory descriptions

Figure 5 Standard Waste Box on Trolley being moved into the large box RTR trailer

Results

The demonstration took place in January 2000 and over the demonstration period 20 FRP crates and other waste containers were radiographed. The radiographic images clearly showed the general nature of the material in the waste container, large metal objects, miscellaneous trash, filters, etc. This technology showed small detail of the contents such as electrical connectors, tubing and fittings, and even folds in the plastic sheeting. Comparison of the image with the inventory description will greatly enhance inventory knowledge. Knowledge of the orientation of the objects within the containers will also enhance container disassembly, processing, and size reduction. Figure 6 shows an RTR image of mixed trash.

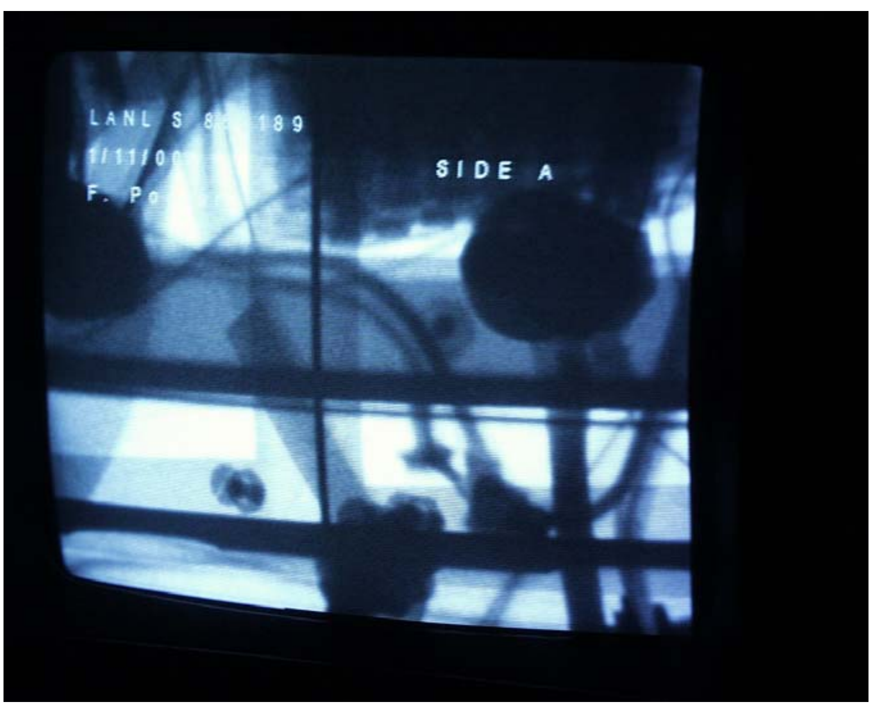


Figure 6 RTR Image of miscellaneous trash

Figure 7 shows the Large Box RTR video monitors that provide the image and x-ray head location information and Figure 8 is a photo of the lead-lined vault.

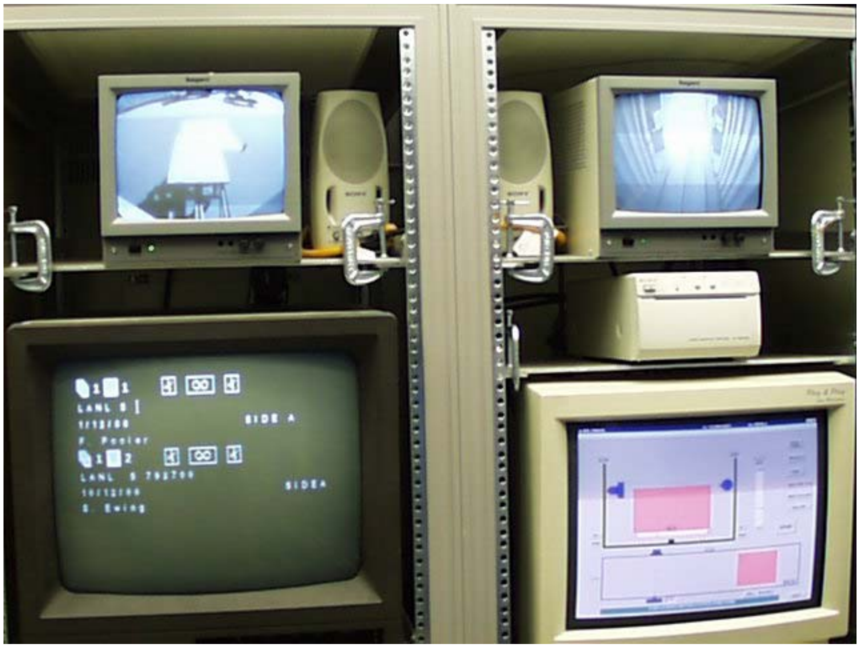


Figure 7 Large Box RTR control console screens

Table 2 provides information on the containers radiographed and the times.

Table 2 Time to radiograph crates in large box RTR demonstration

Crate Number	Crate Contents Description	Dimensions LxWxH [m x m x m (ft x ftx ft)]	Crate Type	Number of Sides RTR'd
S862606	CONTAMINATED HARDWARE	2.4x0.6x0.6 (8x2x2)	FRP	Not averaged*
S865191	CONTAMINATED HARDWARE	2.4x0.6x0.6 (8x2x2)	FRP	1
S865193	CONTAMINATED HARDWARE	2.4x0.6x0.6 (8x2x2)	FRP	1
S811445	DRYBOX SECTION	2.1x1.2x1.2 (7x4x4)	FRP	2
S803228	PIPES AND DISOLVER TANK	2.1x1.2x1.2 (7x4x4)	FRP	2
NA	METAL CYLINDER OF UNKNOWN CONTENTS	13 cm dia x 1 m (5 in dia x 3 ft)	CYL	Not averaged*
S865189	MISC. BLDG. EQUIPMENT	2.1x1.2x1.2 (7x4x4)	FRP	2
S865187	CONTAINMENT VESSEL	2.1x1.2x1.2 (7x4x4)	FRP	2
57455	SHOT DEBRIS	2.4x1.2x1 (7x4x3)	FRP	2
55502	SCRAP METAL	1.2x1.8x1.5 (4x6x5)	plywood	2
S792700	FILTER MEDIA	2.1x1.2x1.2 (7x4x4)	FRP	1
55193	SCRAP METAL	2.4x0.6x0.6 (8x2x2)	plywood	1
S794094	SHOT DEBRIS	2.4x0.6x0.6 (8x2x2)	FRP	1
52652	SCRAP METAL	1.8x1.5x1 (6x5x3)	SWB	1
56581	FILTER MEDIA	1.8x1.5x1 (6x5x3)	SWB	Not Recorded
55503	SCRAP METAL	1.8x1.2x1.5 (6x4x5)	plywood	2
55194	SCRAP METAL	2.4x0.6x0.6 (8x2x2)	plywood	1
52673	SCRAP METAL	1.8x1.5x1 (6x5x3)	SWB	2
56499	SCRAP METAL AND COMBUSTIBLE MATERIAL	1.8x1.5x1 (6x5x3)	SWB	2
55506	COMBUSTIBLE MATERIAL	1.8x1.5x1 (6x5x3)	SWB	1
Average time, all boxes		**28.3 min**		
Average time for boxes scanned both sides		**35.7 min**		
Average time for boxes scanned one side only		**17.3 min**		

* These items were not included in the averaging as the time was interrupted or not considered representative of typical operation.

Each of the test objectives was met and addressed individually.

- Image the contents of oversize waste containers such as large boxes and crates to identify the content of the crates, specifically whether the crates include lead shielding.
  The size restrictions of the trailer precluded imaging many of the glovebox crates as they are generally taller than the x-ray chamber could accept. Standard Waste Boxes and crates that met the size restrictions were selected.
- Identification of lead shielding in the objects to identify crates that are mixed waste
  The first crate radiographed contained a lead shielded test chamber or glovebox. The shielding was clearly visible as opaque or dense material near the gloveport.
- Through content resolution, enhance the health and safety as well as the efficiency of crate opening and subsequent contents handling

One of the first observations made by the RTR technicians was the number of nails and screws used to assemble the FRP crates. These observations led to recommendations on the best locations for sawing into the crates. As a second point, the understanding of the details of the contents of each container will support selection of containers for opening and enhance planning to ensure that proper equipment is in place for disassembly. Specifically, this information identifies any special equipment that may be required for special items, such as containerized liquids. An un-punctured aerosol can was clearly identified in one waste crate.

- Through content resolution, enable an assessment of the site-specific programmatic resources required for TRU oversize waste handling, i.e., manpower forecasting.

  As indicated above, the details and general content of the waste containers was clearly visible and non-compliant items for WIPP certification were identified.

- Confirm container contents inventory descriptions

  Two crates with minimal descriptive information were shown to contain a large and long metal fixture. The inventory information was limited to a three word abbreviated description that was not meaningful. Knowledge that the item is a large metal object will facilitate appropriate planning for the processing operation.

Figure 8 Large Box RTR shielded x-ray chamber

SECTION 4
TECHNOLOGY APPLICABILITY AND ALTERNATIVES

Competing Technologies

The MCS large box RTR technology was selected for demonstration by the Los Alamos ICT to address a need identified by the Los Alamos Solid Waste Operations staff during project meetings with the LSDDP Technology Selection Committee. The baseline DVRS process did not include plans/technologies for radiography of the oversized crates and containers as the technologies were not available at the time of the engineering of the DVRS. LANL considered it a “technical need” as improved knowledge of crate and container contents and the orientation of large metal objects would allow the operations staff to better plan the individual waste container processing and identify the safest location for cutting and opening the packages. As a secondary benefit, it provides the Los Alamos management better information for selecting the first containers to be opened and avoids opening mixed waste containers early in the campaign.

The survey for technologies to radiograph or x-ray waste containers identified two general supplier types. Two suppliers of x-ray systems for trucks and cargo containers were identified. The intent of theses units is identification of contraband in trucks and cargo containers at US border crossings. A Los Alamos LSDDP demonstration of the Vehicle and Cargo Inspection System (VACIS™) was the outcome of this suppler/ technology review. An Innovative Technology Summary Report was written for that demonstration under the OST Reference Number 2912 (DOE, 2000). Systems for RTR of waste drums and Standard Waste Boxes have been operational for several years addressing characterization for wastes destined for WIPP. However, these units could not accept the larger boxes and crates from the Los Alamos retrieval activities due to their size. In early 1999 it was identified that a new RTR unit was under construction to deal with the DOE’s large boxes. This VJ Technologies system was intended to operate in a mode similar to the WIPP characterization systems. This demonstration represents the first deployment of this large box RTR system and is intended to provide performance and cost data on the unit for potential application at other DOE sites.

Comparison of capabilities and costs of the MCS large box RTR system and the VACIS™ system can be made.

Technology Applicability

The technology has direct application for the imaging of large waste containers destined for processing and repackaging as it provides valuable information on detailed container contents and orientation. Although the container size limitations precluded its use on most of the LANL large crates, it is expected that it can be used on the majority of the thousands of crates in DOE.

Patents/Commercialization/Sponsor

The large box RTR system is manufactured by VJ Technologies and operated as a service by Mobile Characterization Services of Albuquerque, New Mexico.

SECTION 5
COST

Methodology

The objective of the cost analysis was to provide interested parties with a cost estimate for implementation of the MCS large box RTR system technology on a production scale at a DOE site. The actual demonstration costs incurred at LANL formed the basis of the cost estimate. To approach realistic implementation costs, additional assumptions were invoked regarding the greater efficiency of a production, rather than demonstration, setting.

The costs of the VACIS™ imaging is a competing technology and described in the ITSR (DOE, 2000). Although the container imaging costs are apparently comparable it must be recognized that the actual output and capabilities of the two systems are different. The VACIS system can accept large or very large containers up to truck size, but provides an image with approximately a one inch resolution capability. The MCS RTR system is slower, but provides small item detail, but is limited in container size. Both technologies represent enabling technologies that enhance the safety and operation of DVRS above the baseline. No costs for characterization of this type were included in the DVRS plans.

Key assumptions for the large box RTR cost estimate includes: (Other assumptions and details on the cost analysis are presented in Appendix B.)

1. The MCS RTR unit is available on a service basis. A quotation for the unit, all MCS supplied labor, mobilization and demobilization costs was provided by MCS and is the basis for this analysis.
2. Equipment to stage the waste containers (forklift and one flatbed truck) and a crew of two equipment operators were assumed to be available at the DOE site at prevailing local equipment and labor rates.
3. Other labor provided by the DOE site includes a site coordinator, site health physics supervisor, and site health physics technicians. The site coordinator and site health physics supervisor are senior staff who will manage the project at the DOE site, including preparation of plans, permits, and approvals.
4. Fully-burdened actual labor rates for LANL personnel were used in this estimate.
5. No overhead factors were applied to other direct costs.
6. The operating protocol was assumed to consist of a) loading of one to two containers on to a flatbed truck, b) driving the flatbed truck to the MCS RTR imaging area, c) forklift positioning of the containers on the MCS RTR unit trolley, d) off loading the container from the trolley at the end of the imaging and returning it to the flatbed truck, and e) the flatbed truck returns to the storage location where the forklift operator off loads the completed containers and places new one on the truck. A production rate of 12 containers per day (60 containers per week) was based on the demonstration's experience with processing of crates.

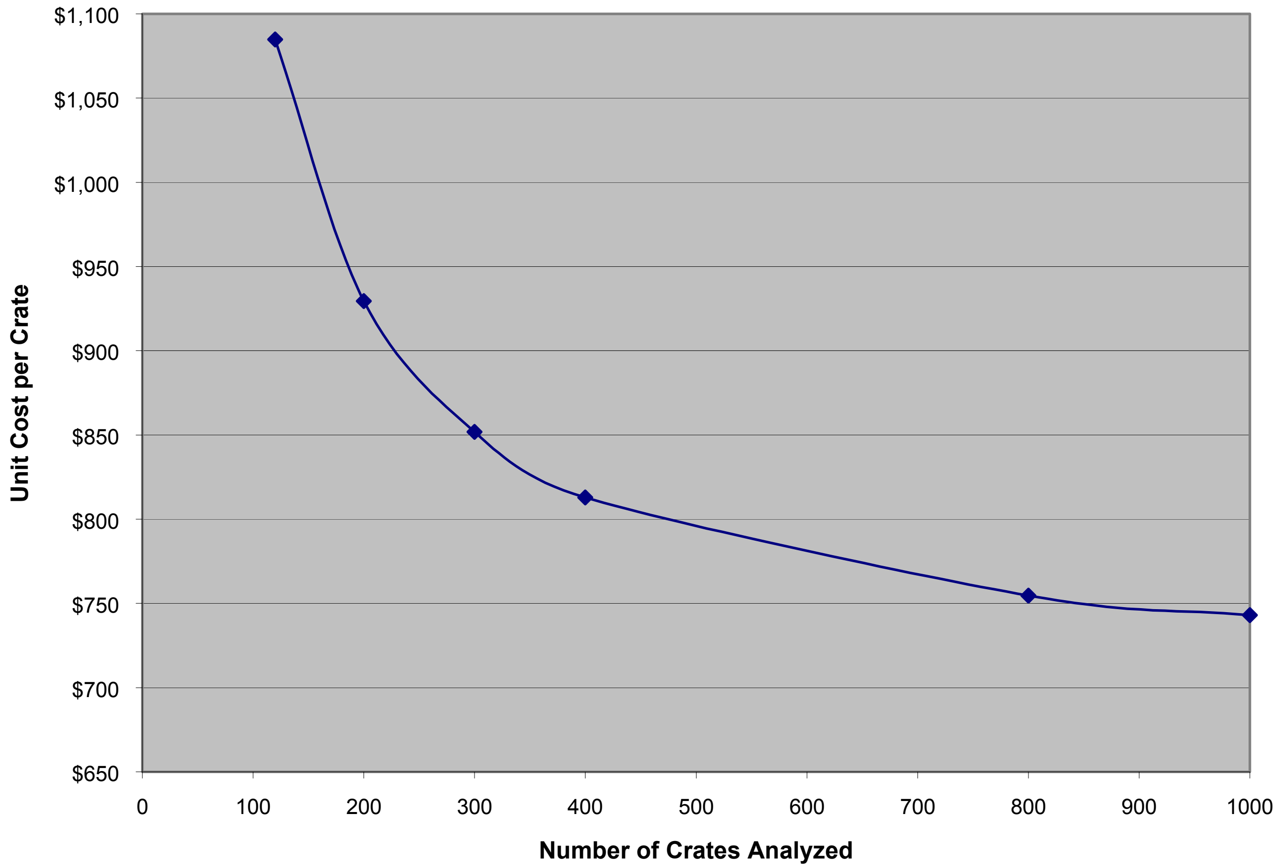
Cost Analysis

To develop an estimate for implementation, a basis of 120 containers was chosen. Activities were grouped under higher level work titles per the work breakdown structure (WBS) shown in the Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS) (U.S. Army Corps of Engineers 1996).

Figure 9 provides a summary of the implementation costs assuming the 120 container basis. The total estimated cost for analysis of 120 containers is approximately $130,000, giving a unit cost of $1,085 per container. The unit cost decreases if more crates than 120 are analyzed per mobilization as shown in Figure 10.

Cost Conclusions

The cost estimate provides a reasonable cost for implementation of MCS large box RTR system radiography at a DOE site. Using the demonstration costs as a basis, costs were developed for



mobilization and planning/permits, radiography, decontamination and equipment release, and demobilization. Radiography costs were scaled to a basis of 120 crates and waste containers, representing two weeks of imaging. Candidate sites may use this basis to scale up to their anticipated costs by considering the number of crates or containers for scanning.

Preparation/permitting costs were a significant component of the total project cost. There were no learning curve efficiencies attributed to these costs because of the likelihood that each DOE site will have permitting requirements that were similar in scope to those required by LANL for the demonstration. An exception might occur if the RTR unit was to make more than one visit to a site. In that case, plans and permits may only require updating.

Figure 9, summarizes the results of the cost analysis. The bars indicate the cost of the individual activities used to calculate a total cost and the line sums the costs. Using a basis of 120 containers, the unit cost for imaging was $1085 each. This per-container cost offers the potential of a positive cost-benefit in light of the enhancements in health and safety and container opening efficiency.

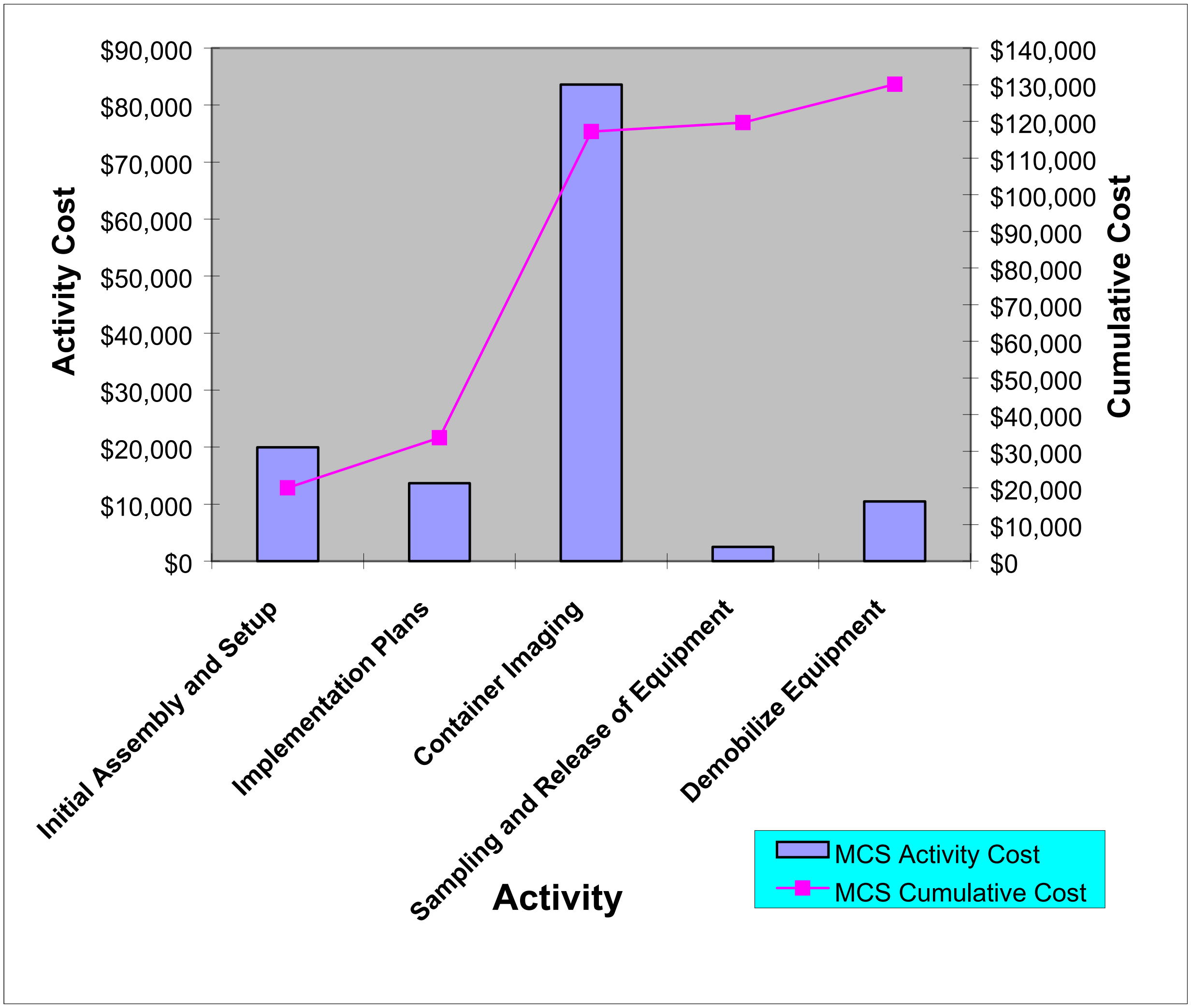


Figure 9 Summary of Implementation Costs for MCS Large Box RTR Imaging of 120 Containers

Figure 10 shows the dependency of the individual container cost on the number of containers to be radiographed. As the number of containers becomes large the fixed costs of mobilization, permitting, and demobilization are diluted and the unit cost drops to less than $750. Note also that if a large number of crates or packages were to be radiographed, expedited container management could further reduce costs.

Figure 10 Total Container Costs for MCS Large Box RTR Imaging

For comparison, the Mobile VACIS™ container cost was calculated to be $634, acknowledging that its capability is quite different. For large numbers of containers the VACIS™ cost drops to less than $400, whereas the MCS unit is $743.

SECTION 6
REGULATORY AND POLICY ISSUES

Regulatory Considerations

As an overweight trailer, special permits were required for shipment of the MCS large box RTR unit. Although this issue is not known to preclude deployment at any DOE site, it can slow the shipment somewhat.

The MCS staff indicated that some states have requirements for x-ray radiography systems and those states may require submittals for compliance.

Safety, Risks, Benefits, and Community Reaction

Worker Safety
The large box RTR technicians were trained radiography technicians. These trained individuals are provided by the service supplier. Radiation monitoring of the workers and attendees at the demonstration was below any reportable quantities and negligible.

Manipulation of large waste containers, including forklift operations, backing and positioning of vehicles and selection and return of crates to inventory poses potential hazards for workers. In particular, the containers must have good integrity to avoid contamination spread.

For workers involved in the opening of the waste containers and the resizing of the contents, worker safety can clearly be enhanced by the radiographic images provided by the large box RTR system. An image of the contents allows the worker to better position initial cuts into the container, and allows the subsequent removal and resizing operations to be tailored to the contents of the package. The identification of special items, such as aerosol cans also allows the workers prepare for the items and avoid delays.

Community Safety
Community safety is not adversely affected by operation of the large box RTR unit. It will not significantly increase the background radiation in an area.

Environmental Impact
There is no negative environmental impact and a potential positive impact to use of the large box RTR unit. The positive impact consists of the health and safety provisions that can be implemented as a result of the knowledge of specific container contents. This allows environmental containment controls to be designed appropriately.

Socioeconomic Impacts and Community Reaction
There are no socio-economic impacts associated with the large box RTR unit. Community reaction is likely to be positive given the enhancements to both worker and environmental safety that are obtained.

SECTION 7
LESSONS LEARNED

Implementation Considerations

The large box RTR demonstration at LANL yielded several lessons learned including:

- Site-specific health and safety requirements, including daily radiation monitoring, source mobilization and demobilization and health and safety meetings can comprise 25 to 30-percent of the available operational time.
- Logistics in handling of the large FRP crates and other containers are important for efficient system utilization. The unit can radiograph the crates and containers in 15 minutes to one hour. The management of the waste containers caused much “down time” in the trailer waiting for radiation control technician results and container delivery. If possible, all container surveys and smears should be made prior to deployment of the RTR unit, and thereby improve the daily throughtput.
- Adequate time should be budgeted for site-specific procedure approvals. Therefore, it is important to engage the reviewers/ approvers at the earliest time to identify and address issues. In this demonstration the crew assembled for a demonstration period in December, but authorization was incomplete.

Technology Limitations and Needs for Future Development

The Los Alamos demonstration conclusively proved that MCS large box RTR unit will accomplish the task it was designed for, radiography waste containers for identification of contents and location of items prohibited from disposal at WIPP. It provides DOE good information on the size, orientation, and metallic thickness of crated metal objects. Although not expected, the ability to identify containerized liquids would also enhance the operation of DVRS.

For the DOE Complex-wide application, the large box RTR system can provide a very valuable service to many sites and radiograph the vast majority of waste containers. However, for this specific LANL application, the size limitations seriously impact the system utility. A second shortcoming is the inability of the system to provide a single image of the entire container. MCS indicates that this capability could be added to the system, but is not currently available. The availability of a single compiled image of the complete container would improve the ability to identify and process the large metal items.

Technology Selection Considerations

Considerations for selection of this technology include:

- An interest in the details of the contents of waste containers, including the potential for containerized liquids.
- The containers meet the size limitations of the system: 113-inches long by 77-inches wide and 77-inches tall
- To take advantage of the throughput capacity, the logistics of containers positioning should be arranged in advance, including possible pre-positioning. This would optimize the large box radiography cost.
- Since the waste containers are actually taken in to the RTR trailer, damaged or contaminated containers must be packaged to avoid contamination of the unit.

Figure 11 Image of Aerosol can in crate

APPENDIX A
REFERENCES

IT Corporation, September 1999, Project Specific Test Plan for the Field Demonstration of the MCS Large Box Real Time Radiography Mobile System

U.S. Army Corps of Engineers, 1996, Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary

U.S. Department of Energy, Waste Crate and Container Imaging Using the Vehicle and Cargo Inspection System, Innovative Technology Summary Report, July 2000. Office of Science and Technology reference number 2912.

APPENDIX B
Cost Details

Basis of Estimated Cost

The activity titles shown in this cost analysis for implementation were derived from quotations for the demonstration at Los Alamos and from a reasonable estimate of the level of effort required for implementation at other DOE sites. In the estimate, the activities are grouped under higher level work titles per the work breakdown structure shown in the Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure and Data Dictionary (HTRW RA WBS) (U.S. Army Corps of Engineers 1996). The HTRW RA WBS, developed by an interagency group, is used in this analysis to provide consistency with the established national standards. The costs shown in this analysis are computed form observed duration and hourly rates for the crew and equipment.

Activity Descriptions

The scope of each WBS element, computation of production rates, and assumptions (if any) for each work activity are described in this section. The subcontractor service costs are derived from their proposal and subcontract for the activities during the Los Alamos demonstration.

Mobilization and Preparatory Work (WBS 33.1.01)
*Mobilization of Equipment –T*he MCS large box RTR unit was mobilized from the VJ Technologies facility on Long Island NY. A cost of $19,500 delivered the trailer to Los Alamos, provided for MCS supervision of the trolley rail setup, and submission of the operation procedures and hazards analyses necessary for site authorization. Two LANL technicians supported the trolley rail assembly for ½ day.

Submittals/Implementation Plans – Plans and permits were assumed to be completed prior to the start of work. It was estimated that the Site Health Physics Supervisor and a Site Health Physics staff person will each require 40 hours to develop plans and permits. The Site Coordinator, who will manage the operation at the site, will require 80 hours to prepare for the work and develop the plans and permits. A Site Radiation Control Technician will require 9 hours for plan/permit support.

Monitoring, Sampling and Testing (WBS 33.1.02)
Waste Container Imaging - Based on the LANL demonstration, it was assumed that Site Equipment Operators will load the containers to be radiographed onto flatbed trucks using a forklift, after which the flatbed truck will be driven to the RTR trailer for radiography. A forklift will position the container on the RTR trailer trolley. After radiography, the forklift operator will exchange the imaged container for a replacement that is positioned on the flatbed truck. This process is then repeated for additional containers. The average time for radiography (container positioned on the trolley to removal from the trolley was 28 minutes. Based on logistical constraints such as space required to stage containers for loading and return to storage, a reasonable rate of 12 containers per day (8 hour period) was achieved and is estimated for future implementation. For this estimate, a processing rate of 12 containers per day and 60 containers per week was assumed.

The cost for two weeks of service by MCS in the demonstration was $58,709. This included the radiographers, management, their travel expenses, and expendables. The site crew includes:

- One truck driver/ forklift spotter
- One forklift operator
- One radiation control technician
- One site operations engineer to manage crate selection and handling.

Equipment Decontamination and Release – Smear sampling of all offsite equipment was required prior to release. Based on this demonstration, 8 hours was required for equipment sampling and release.

Demobilization (WBS 33.1.21)
Demobilization of Equipment and Personnel – The demobilization charges by MCS for the large box RTR system were $10,000 and included staff to disassemble the trolley rail and make electronics in the trailer "travel-ready". A commercial driver moved the trailer.

LANL support involved two operations technicians to support disassembly for ½ day.

Cost Estimate Details

The cost analysis details are summarized in Table B-1. The table breaks out each member of the crew, each labor rate, each piece of equipment used, each equipment rate, each activity duration, and all production rates so that site-specific differences in these items can be identified and a site-specific cost estimate can be developed.

WBS Activity	Labor	Equipment	Unit of Measure	Unit Cost	Quantity	Subtotals
Mobilization and Preparatory Work (WBS 33.1.01)						$ 33,638
Mobilize Equipment						*$ 19,966*
	Site Equipment Operators		hour	$ 58.25	8	$ 466
		Ship MCS to site	lump	$ 19,500.00	1	$ 19,500
Submittals/Implementation Plans						*$ 13,672*
	Site Health Physics Super.		hour	$ 80.46	40	$ 3,218
	Site H&S Staff		hour	$ 71.19	40	$ 2,848
	Site Coordinator		hour	$ 89.63	80	$ 7,170
	Site Radiation Control Tech.		hour	$ 48.45	9	$ 436
Monitoring, Sampling & Testing (WBS 33.1.02)						$ 83,575
Container Imaging						*$ 83,575*
	Site Coordinator		hour	$ 89.63	80	$ 7,170
	Site Radiation Control Tech.		hour	$ 48.45	80	$ 3,876
	Site Equipment Operators		hour	$ 58.25	160	$ 9,320
		MCS Unit	lump	$ 58,709.00	1	$ 58,709
		Forklift - 8 ton	hour	$ 37.50	80	$ 3,000
		Flatbed Truck	hour	$ 18.75	80	$ 1,500
Decontamination/Decommissioning (WBS 33.1.17)						$ 2,487
Release of Equipment						*$ 2,487*
	Site Coordinator		hour	$ 89.63	8	$ 717
	Site Radiation Control Tech.		hour	$ 48.45	8	$ 388
	Site Equipment Operators		hour	$ 58.25	16	$ 932
		Forklift - 8 ton	hour	$ 37.50	8	$ 300
		Flatbed Truck	hour	$ 18.75	8	$ 150
Demobilization (WBS 33.1.21)						$ 10,466
Demobilize Equipment						*$ 10,466*
	Site Equipment Operators		hour	$ 58.25	8	$ 466
		MCS Unit	lump	$ 10,000.00	1	$ 10,000

Figure B-1 Implementation Cost Detail for a 2 Week Period, 120 crates (12 per day)

APPENDIX D
ACRONYMS AND ABBREVIATIONS

Ci	Curie
DOE	U.S. Department of Energy
D&D	Decontamination and Decommissioning
DDFA	Deactivation and Decommissioning Focus Area
DVRS	Decontamination and Volume Reduction System
G&A	General and Administrative
FRP	fiberglass reinforced plywood
HTRW RA WBS	Hazardous, Toxic, Radioactive Waste Remedial Action Work Breakdown Structure
ICT	Integrating Contractor Team
LANL	Los Alamos National Laboratory
LSDDP	Large-Scale Demonstration and Deployment Project
MCS	Mobile Characterization Services
NETL	National Energy Technology Laboratory
OST	Office of Science and Technology
PPE	Personal Protective Equipment
RCRA	Resource Conservation and Recovery Act
RCTs	Radiation control technicians
RMA	Radioactive Material Area
SWBs	standard waste boxes
TLD	thermal luminescent detector
TMEC	US Army’s Thunder Mountain Test and Evaluation Center
TMS	Technology Management System
TRU	transuranic
US	United States
VACIS™	Vehicle and Cargo Inspection System
WBS	work breakdown structure
WIPP	Waste Isolation Pilot Plant